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Exploration of Curriculum Reform in Data Management and Analysis for Medical Research

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Abstract: *Objective:* To explore the effectiveness of integrating scenario-based learning (SBL) with case-based learning (CBL) in teaching data management and analysis in medical research. *Methods:* Students in the preventive medicine program at Nanjing Medical University were divided into two cohorts: the 2020 cohort received CBL-only instruction, while the 2021 cohort underwent combined SBL-CBL teaching. Teaching effectiveness was evaluated through process assessment and final skill examination. *Results:* The SBL-CBL group achieved significantly higher final comprehensive scores than the CBL group (86.33 ± 6.37 vs. 79.50 ± 14.38). All question-type scores improved. In process assessment, the CBL group scored higher overall (17.19 ± 1.89 vs. 16.31 ± 2.04), a difference mainly attributed to peer evaluations. *Conclusion:* The integration of SBL and CBL has significantly enhanced students' comprehensive data analysis skills, providing empirical evidence for teaching reform in the field of public health.

Keywords: Scenario-based learning; Case-based learning; Data analysis; Process assessment

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1. Introduction

Within China's current higher medical education system, Epidemiology and Medical Statistics provide the theoretical foundation for population-based research, addressing study design and statistical analysis, respectively [1,2]. Building on this foundation, Data Management and Statistical Analysis in Medical Research (hereafter Data Analysis) is a practice-oriented, interdisciplinary course that integrates these two fields. The course emphasizes the efficient use of statistical software for data entry, organization, quality control, analysis, and interpretation in real-world contexts, aiming to develop students' competence in addressing practical health-related problems [3–5].

Case-based learning (CBL) has been shown to enhance students' problem-solving skills; however, in data analysis courses, it often prioritizes technical execution over contextual understanding [6]. Scenario-based learning (SBL) creates learning scenarios that closely replicate real-world work, guiding students to "learn by doing"; nevertheless, its application in data analysis courses remains limited [7]. Evidence suggests that

combining multiple teaching approaches can increase learner engagement and strengthen overall competence [8]. Accordingly, this study integrates SBL and CBL to evaluate their effectiveness in the Data Management and Analysis in Medical Research course, providing empirical support and practical insights for educational reform within the framework of "Double First-Class" discipline development.

2. Subjects and methods

2.1. Study population

Undergraduate students majoring in preventive medicine from two classes in the 2020 grade and two classes in the 2021 grade at our university were included in this study. A total of 62 students from the 2020 grade and 55 students from the 2021 grade were enrolled. Before participation, students in both grades had completed the courses in Epidemiology and Medical Statistics. There were no statistically significant differences in the grades of these related courses between the two groups ($P > 0.05$).

2.2. Teaching methods

The course consisted of 27 class hours and covered questionnaire design and quality control, data entry and management, descriptive statistics, intergroup comparison, and correlation and regression analyses. All teaching sessions were conducted in a computer laboratory, followed by a comprehensive practical session at the end of the course.

For students in the 2020 grade, a CBL-only teaching approach was adopted. Based on typical epidemiological and clinical research cases presented in the textbook, the instructor demonstrated software operations according to the teaching objectives of each case, while students followed the procedures simultaneously and completed the corresponding analytical tasks. The classroom was organized through a combination of teacher instruction and student practice.

For students in the 2021 grade, an integrated SBL-CBL teaching model was adopted. Using "the full process of lung cancer screening implementation in China" as the simulated scenario, the teaching content was systematically organized into six consecutive modules: questionnaire design and survey for high-risk populations for lung cancer, questionnaire data entry, epidemiological database management, individualized lung cancer risk assessment, comparative analysis between screening-positive and screening-negative populations, and analysis of factors associated with lung cancer detection [9]. The entire teaching process was conducted within the context of the screening workflow. Students participated in scenario simulation in groups, clarified task objectives, and collaboratively completed the data analysis. The instructor mainly provided explanations and demonstrations for common problems, and the teaching process was reinforced through presentation and discussion.

2.3. Outcome evaluation

Teaching effectiveness was evaluated comprehensively by a computer-based data analysis skills examination and multidimensional formative assessment. The examination was conducted in the form of a computer-based practical test, requiring students to perform database quality control, data organization, and statistical analysis using simulated community survey data on chronic disease risk factors. The examination papers for the 2020 and 2021 grades were required to be consistent in question type, number of items, and difficulty. The examination score accounted for 80% of the final grade. In addition, multidimensional assessment was

conducted in this course, including intergroup peer evaluation (10 points), intragroup peer evaluation (5 points), and teacher evaluation based on attendance and classroom performance (5 points). The sum of these three components constituted the total formative assessment score.

2.4. Statistical analysis

Final examination scores and formative assessment scores were expressed as mean ± standard deviation (SD), and comparisons between the two groups were performed using the independent-samples *t*-test. In addition, according to the score distribution, the Mann-Whitney rank-sum test was used to compare differences in score distribution between the two groups after the teaching reform. All data analyses were performed using R software (version 4.3.2). A two-sided α of 0.05 was considered statistically significant.

3. Results

3.1. Comparison of overall performance

In terms of overall performance, students taught using the CBL-only approach achieved a mean score of 79.50 ± 14.38, whereas the mean score increased significantly to 86.33 ± 6.37 after implementation of the integrated SBL-CBL teaching model, with a statistically significant difference between the two groups ($P = 0.002$). In terms of grade distribution, the proportion of students rated as excellent increased from 25.8% to 34.5%, and the proportion rated as good increased from 32.3% to 45.5% after the teaching reform. The distribution of performance grades differed significantly before and after the reform ($P = 0.014$) (**Table 1**).

Table 1. Comparison of overall academic performance between the CBL group and the integrated SBL-CBL group

	CBL group(n = 62)	SBL-CBL group(n = 55)	P value
Total score, mean ± SD	79.50 ± 14.38	86.33 ± 6.37	0.002
Excellent, *n* (%)	16 (25.8%)	19 (34.5%)	
Good, *n* (%)	20 (32.3%)	25 (45.5%)	
Moderate, *n* (%)	12 (19.4%)	10 (18.2%)	0.014
Pass, *n* (%)	12 (19.4%)	1 (1.8%)	
Fail, *n* (%)	2 (3.2%)	0 (0.0%)	

3.2. Comparison of performance in the data analysis skills examination

In the computer-based data analysis skills examination, the mean score of the CBL-only group was 77.89 ± 16.37, which was significantly lower than that of the integrated SBL-CBL group (87.53 ± 6.45) ($P < 0.001$). Further comparison by question type showed that, after implementation of the integrated teaching model, students achieved significantly higher scores on fill-in-the-blank questions, short-answer questions, and comprehensive analysis questions (all $P < 0.001$). Among these, the improvement in comprehensive analysis questions was particularly notable, with a mean increase of nearly 5 points, indicating that the integrated SBL-CBL teaching model was more conducive to the development of students' comprehensive data analysis ability (**Table 2**).

Table 2. Comparison of scores for each component under different teaching models

Component	CBL group (n = 62)	SBL-CBL group (n = 55)	Mean difference (95% CI)	P value
Data analysis skills examination				
Total score, mean ± SD	77.89 ± 16.37	87.53 ± 6.45	9.6 (5.16~14.12)	<0.001
Fill-in-the-blank questions, mean ± SD	23.92 ± 5.24	27.01 ± 2.06	3.08 (1.65~4.52)	<0.001
Short-answer questions, mean ± SD	15.02 ± 2.95	16.75 ± 1.16	1.74 (0.93~2.54)	<0.001
Comprehensive analysis questions, mean ± SD	38.64 ± 8.18	43.76 ± 3.22	4.82 (2.58~7.06)	<0.001
Formative assessment				
Total score, mean ± SD	17.19 ± 1.89	16.31 ± 2.04	-0.88 (-1.61~-0.16)	0.017
Intergroup peer assessment, mean ± SD	8.60 ± 0.95	8.15 ± 1.02	-0.45 (-0.80~-0.08)	0.023
Intragroup peer assessment, mean ± SD	4.28 ± 0.86	3.85 ± 1.10	-0.43 (-0.80~-0.07)	0.019
Teacher evaluation, mean ± SD	4.31 ± 0.69	4.31 ± 0.68	0.00 (-0.26~0.24)	0.966

3.3. Comparison of formative assessment performance

In terms of formative assessment, the CBL-only group achieved a significantly higher score than the integrated SBL-CBL group (17.19 ± 1.89 vs 16.31 ± 2.04, P = 0.017). Further analysis indicated that this difference was mainly attributable to intergroup and intragroup peer assessment, whereas no significant difference was observed in teacher evaluation between the two groups (**Table 2**). This finding suggests that, after the teaching reform, greater demands were placed on students' initiative and participation, and performance in peer assessment more directly reflected their level of engagement in the course.

4. Discussion

4.1. The integrated SBL-CBL teaching model improved students' comprehensive analytical ability

In recent years, the combined application of SBL and CBL has become an important focus of medical education reform. Previous studies have shown that these approaches are superior to traditional lecture-based teaching in promoting learning initiative, clinical reasoning, and teamwork skills [10]. In the present study, scenario simulation was incorporated into the conventional CBL framework, and teaching cases were reorganized into a coherent logical sequence, thereby forming an integrated SBL-CBL teaching model. The results showed that this model significantly improved students' comprehensive data management and analytical ability [11,12]. One possible explanation is that scenario simulation embedded abstract data analysis into authentic public health contexts, such as lung cancer screening, and required students to apply epidemiological and statistical knowledge to solve practical problems [10]. This may have enhanced the contextual relevance and practical value of the teaching process.

4.2. Interpretation of differences in formative assessment scores

The traditional CBL group achieved higher formative assessment scores than the integrated teaching group, and this difference was mainly derived from the peer-assessment component. Under the traditional CBL model, task structures were relatively explicit, making individual contributions easier to identify and peer-assessment results more concentrated. By contrast, SBL-based scenario simulation involved greater task complexity and a more open learning process, placing higher demands on student autonomy and implicit cognitive engagement [13]. Under these conditions, some forms of learning contribution may not have been readily perceived by peers, thereby influencing peer-assessment outcomes. Therefore, this difference is more likely to reflect a mismatch between the evaluation approach and the transformed teaching model than insufficient effectiveness of the integrated teaching strategy itself [14]. This finding suggests that formative assessment indicators should be further refined to better capture deep participation and higher-order competence development.

5. Conclusion

Overall, the integrated SBL-CBL teaching model showed clear advantages in improving student performance in the course of medical research data management and analysis. These findings support the promotion of teaching approaches organized around authentic professional scenarios, particularly in the context of the New Medical Sciences initiative, which emphasizes interdisciplinary integration and data-enabled medical education. At the same time, greater support should be directed toward virtual simulation platforms, professional software tools, and real-world data resources, together with the development of virtual scenario cases and interactive analytical environments aligned with course objectives. Such efforts may help advance medical data analysis education in China toward greater quality and practical relevance.

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Disclosure statement

The authors declare no conflict of interest.

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